Fire Hazard Analysis
Building 1000
Relativistic Heavy Ion Collider (RHIC)

Brookhaven National Laboratory

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1.0 OVERVIEW AND RECOMMENDATIONS

1.1 Purpose and Methodology

A Fire Hazard Analysis (FHA) was performed for Building 1000, the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL), Upton, NY. This report fulfills the requirement for documentation of an FHA as outlined in DOE Order 420.1, Facility Safety. This FHA assesses the risk from fire in Building 1000 to ascertain whether the facility meets the objectives of DOE Order 420.1 and the Brookhaven National Laboratory (BNL) Fire Safety Program. The fundamental goal of the BNL Fire Safety Program is to control fire risks such that:

1. Public and employees are not unreasonably endangered by fire;
2. Vital Laboratory missions are maintained without significant interruption from fire;
3. Property losses are limited to less than $1 million dollars per occurrence, and lower when justified by cost-effective, risk reduction measures;
4. Damage to the environment is averted; and
5. The potential for occurrences of fires are avoided whenever economically feasible.

This FHA is an evaluation of the fire hazards (1) that expose Building 1000 and (2) that are inherent in the building or operations. The adequacy of the fire safety features in the building and the degree of compliance of the facility with specific fire safety provisions in DOE orders, and related engineering codes and standards, were determined. The results of the analyses are presented in terms of the fire hazards present, the potential extent of fire damage, and the impact on employee and public safety.

The general approach taken to complete this evaluation involved the identification of fire hazards in the building and the fire protection features required to mitigate the adverse consequences of a fire. A determination was made as to the adequacy of the proposed fire protection features to effectively control the fire hazards. Concerns for the protection of safety systems, critical processes, and life safety of building occupants from fire were essential considerations in the analysis. Compliance was determined by a comparison of existing conditions found during the site visits with current code requirements. Where conflicting requirements were found the more conservative requirements were used in this evaluation.

Maximum Possible Fire Loss (MPFL) and Maximum Credible Fire Loss (MCFL) potentials were also evaluated. The MPFL, as defined in DOE Order 420.1, is the value of property within a fire area, unless a fire hazard analysis demonstrates a lesser (or greater) loss potential, assuming the failure of both automatic fire suppression systems and manual fire fighting efforts. The MCFL, as defined in DOE Standard 1066-99 Fire Protection Criteria, is the value of property within a fire area, unless a fire hazard analysis demonstrates a lesser (or greater) loss potential. This assumes that all installed fire protection systems function as designed, and the effect of emergency response is omitted except for post-fire actions. Both MPFL and MCFL fire loss estimates are to include the replacement cost of equipment and property and any applicable decontamination and cleanup costs.

The MPFL scenario was based on a qualitative consideration of several factors; the potential to reach flashover conditions based on combustible loading and the geometry of the space(s) under consideration; adequacy of passive protection features; and continuity of combustibles.

The MCFL scenario is one in which automatic suppression systems function as designed. Since properly designed and installed sprinkler systems should limit the fire growth and/or damage to the design area of the system, this floor area is used in the determination of MCFL potentials when protected by automatic sprinkler systems. Without sprinkler protection the MCFL is the same as the postulated MPFL for that area.

MPFL and MCFL potentials were determined based on an average dollar density of the building replacement value divided by the floor area of the building. Building values were obtained from 2004 replacement costs. The content and equipment values were calculated based on the following assumptions:

- An average of $20/ft^2 for content and equipment value within predominantly office areas.
- An average of $100/ft^2 for content and equipment value within the industrial and experimental areas of the building.

The above cost assumptions are considered adequately conservative to address the requirement to include decontamination and cleanup costs.

A qualitative assessment of the risk presented by conditions found to be deficient was also performed and is included in Section 1.3, Findings and Recommendations. This assessment was made by assignment of a risk assessment code (RAC). The RAC methodology is used in a number of industries as a tool to qualitatively prioritize deficiencies and corrective actions and is derived as follows:

1. Hazard Severity. An assessment of the worst potential consequence, defined by degree of occupational injury, illness or property damage which is likely to occur as a result of the deficiency. Hazard severity categories shall be assigned by roman numerals according to the following criteria:

    a. Category I. May cause death, permanent total disability, or loss of a facility/asset.

    b. Category II. May cause permanent partial disability, temporary total disability in excess of 90 days (severe injury or severe occupational illness), or major property damage.

    c. Category III. May cause minor injury, occupational illness, or property damage.

    d. Category IV. Presents minimal threat to personnel safety or health, or property, but is still in violation of a standard.

2. Mishap Probability. The probability that a hazard will result in a mishap or loss, based on an assessment of such factors as location, exposure (cycles or hours of operation), affected populations, experience, or previously established statistical information. Mishap probability shall be assigned an English alphabet symbol according to the following criteria:

   a. Subcategory A. Likely to occur immediately or within a short period of time. Expected to occur frequently to an individual item or person or continuously to a fleet, inventory or group.

   b. Subcategory B. Probably will occur in time. Expected to occur several times to an individual item or person or frequently to a fleet, inventory or group.

   c. Subcategory C. May occur in time. Can reasonably be expected to occur some time to an individual item or person or several times to a fleet, inventory or group.

   d. Subcategory D. Unlikely to occur.

3. Risk Assessment Code. Using the matrix shown below, the RAC is expressed as a single Arabic number that is used to help determine hazard abatement priorities.

Hazard Severity	Mishap Probability			
	A	**B**	**C**	**D**
I	1	1	2	3
II	1	2	3	4
III	2	3	4	5
IV	3	4	5	6

RAC Definitions

1-Critical
2-Serious
3-Moderate
4-Minor
5 & 6-Negligible

1.2 Summary

Building 1000, the Relativistic Heavy Ion Collider which supports the NASA Space Radiation Laboratory, The AGS and RHIC programs, was constructed in 1987 and commissioned in 1991 and is 12,197 square feet.

The descriptions are based on field surveys, a review of the as-built documents, and discussions with BNL staff. This assessment and FHA demonstrates the achievement of a reasonable and equivalent level of fire safety that meets DOE improved risk objectives.

Overview of the BNL

This Fire Hazards Analysis (FHA) has been performed to comprehensively assess the risk from fire in Building 1000, the Relativistic Heavy Ion Collider (RHIC). The RHIC facility consists of a beam injection system, two superconducting magnet beam storage rings, six experimental halls, and a number of support buildings. Accelerated protons, deuterons or heavy ions in counter-rotating beams, each in separate rings, may be brought into collision at five different locations where experiments are conducted. The particle cascade produced by the colliding beams is recorded by various instruments to study nuclear phenomena in detail.

This FHA includes an analysis of the fire and life safety features of the facility to determine the level of compliance with DOE Order 420.1 Fire Protection objectives.

Based on the analysis, it has been determined that Building 1000 generally complies with DOE Order 420.1 Fire Protection objectives.

1.3 Findings and Recommendations

1.3.1 New Findings and Recommendations

None

1.3.2 Outstanding Recommendations from Previous Reviews

None

2.0 SCOPE

This FHA is based on information supplied by the Accelerator Department staff, a survey of the facility conducted in November 2006, and a review of available drawings.

The following codes and standards were utilized for this evaluation:

The Building Code of New York State 2002 Edition (BCNYS)

International Code Council (ICC), International Building Code (IBC) 2003 Edition;

ICC, International Fire Code (IFC) 2003 Edition

National Fire Protection Association (NFPA) Codes, Standards, and Recommended Practices – See Section 9 (Reference Documents) of this report for a complete list.

3.0 LOCATION

Building 1000 is located in the north central region of Brookhaven National Laboratory (BNL). BNL is a 5,000 acre site owned by the Department of Energy and operated by Brookhaven Science Associates. BNL is located in Upton, New York.

4.0 CONSTRUCTION

4.1 Occupancy Classification

Building 1000, the RHIC, is classified by BCNYS (Sec. 306.1) as "Factory Industrial F-2 Low Hazard" occupancy." NFPA 101 (3.3.152.8.3) classifies this buildings as "Industrial, Special Purpose" occupancy.

4.2 Construction Type

The RHIC is a one-story, tunnel with a total circumference of 12,578 feet (including the intervening Experimental Halls, which are 2,578 linear feet of the circumference). The cross sectional dimensions are 11-feet, 1-inch high at the center and 15-feet, 4-inches wide at the floor. The tunnel is covered with 13 to 19 feet of earth for radiation shielding. The RHIC uses superconducting magnets to bend and focus the beam. The magnets are cooled to 4.6K supercritical helium gas. At cryogenic temperature, the magnets acquire superconducting properties, thereby greatly reducing the amount of electricity which must be supplied to generate the magnetic field. Accelerated particles from counter rotating beams in separate rings are then steered into collision with a detector system. The detectors analyze and categorize the secondary particles resulting from the collision. The interior finish is of unfinished galvanized steel with bare concrete on the floor.

The building construction type is BCNYS IIB and NFPA Type II (000). This is an underground structure with corrugated steel walls covered with earth that do not have a known fire resistive rating.

The RHIC machine is enclosed in a tunnel, 12 feet underground. Inside the two tubes ion bunches travel around RHIC's 2.4 mile ring in opposite directions. The ion beams inside the two tubes are referred to as the yellow and blue beams. Each Collider ring is made of hundreds of magnets. RHIC's magnets differ from those at the AGS because RHIC magnets are superconducting, using niobium titanium wire to carry the electrical current. Each magnet cylinder contains the steel magnet plus the cryogenic and electrical distribution systems. Like AGS, ion beams travel in a vacuum pipe in the middle.

RHIC's 2.4-mile ring has six intersection points where its two rings of accelerating magnets cross, allowing the particle beams to collide. The collisions produce the fleeting signals that, when captured by one of RHIC's experimental detectors, provide physicists with information about the most fundamental workings of nature. If RHIC's ring is thought of as the face of a clock, the four current operations are at 6 o'clock (STAR), 8 o'clock (PHENIX), 10 o'clock (PHOBOS) and 2 o'clock (BRAHMS). These experimental detectors are addressed in separate Fire Hazards Analyses.

Additionally, there is a polarized-hydrogen-gas target (JET) in RHIC used for elastic scattering measurements when polarized proton beams are circulating. The JET target is located at the 12 o'clock intersection point and the yellow and blue beams in RHIC are separated by about 10 mm instead of colliding. Only one beam at a time interacts with the JET target.

The RHIC uses superconducting magnets to contain, bend, split and focus the beam. The magnets are located within the walls of the accelerator ring as well as within sections of the beam lines. The magnets in RHIC are cooled to 4.5° K using supercritical helium gas. Helium will remain liquid at 1 atmosphere pressure provided the temperature does not rise above 4.2° K.

The primary combustible loading in the injectors, accelerators, Collider and experiments consists of magnets, power and control cables, and beam diagnostic equipment located throughout the complex. None of the materials is highly flammable, and with the possible exception of small amounts of control cable, all are expected to self-extinguish upon the de-energizing of electric power. Small amounts of flammable materials are routinely used in support of the accelerator operations and experiments.

Life Safety Code

The LSC does not specify a minimum construction type for existing special purpose industrial occupancies [§39.1.6; §40.1.6]. The LSC permits an occupant load of not more than 1,000 persons and located at the level of exit discharge to be within a building of Type II(000) construction regardless of automatic sprinkler protection [LSC Table 13.1.6]. Thus, the existing construction complies with LSC requirements.

Building Code of New York State

Section 503 and Table 503 of the BCNYS contain criteria for the allowable height and area of buildings based on their occupancies and construction type. Building 1000 is listed as 256,548 (gross) square feet in area.

International Building Code

In accordance with the IBC, Buildings and structures designed to house low-hazard industrial processes that require large areas and unusual heights to accommodate craneways or special machinery and equipment including, among others, rolling mills; structural metal fabrication shops and foundries; or the production and distribution of electric, gas or steam power, shall be exempt from the height and area limitations of Table 503 [IBC 503.1.2].

4.3 Passive Fire Protection

Passive fire protection features include fire-resistive construction, fire doors, fire windows, and fire and smoke dampers. The features are provided to limit fire spread and damage from the area of fire origin to other portions of the building. Due to the nature of the RHIC, interior passive fire protection features are not provided.

4.3.1 Fire Areas

A fire area is defined as a portion of a building that is bounded by a combination of fire-resistive walls and floor/ceiling assemblies, and/or exterior walls. In DOE facilities, fire areas are typically provided for property protection. The Implementation Guide for DOE Order 420.1 requires credited fire areas to be separated from the remainder of the building by a minimum of 2-hour fire barriers (walls and horizontal assemblies). Fire areas may also be provided for compliance with building code limitations for building additions.

Building 1000 is not subdivided. The facility complies with the codes of record with respect to occupancy separations. There are no areas in this facility that are defined as incidental or accessory occupancy use areas as noted in BCNYS "§302.1.1" or NFPA 101 §6.1.14.1.2 and "§6.1.14.1.3."

5.0 FIRE PROTECTION

Existing fire protection systems that provide protection to full or segmented portions of this facility can be classified in four categories; Automatic Fire Suppression Systems, Fire Alarm, Automatic Detection Systems, and Fire Extinguishers. The following is a description of the existing installed systems in the building.

5.1 Automatic Fire Suppression Systems

5.1.1 Site Water Supply

BNL has a combination domestic and fire protection water supply system. The system is supplied by several deep wells and is stabilized by two elevated water storage tanks (one 1 million gallon and one 300,000 gallon capacity). The wells have electric primary drivers and a limited number have backup internal combustion drivers. The system can sustain three days of domestic supply and a maximum fire demand (4,000 gallons per minute (GPM) for 4 hours) for BNL with two of the system's largest pumps out of service and one storage tank unavailable. The piping distribution network is well gridded. The distribution system in the vicinity of Building 1000 has a static supply pressure of 52 pounds per square inch (PSI) at low elevated tank levels; 65 psi normally. The water supply system in the area can supply about 5,500 GPM at 20 PSI (based on the Water Distribution Model Analysis developed by the Fire Protection Engineering Group during the summer of 2004.)

Frost proof Fire hydrants are provided within 300 ft of the entrances into the tunnel. Frost proof hydrants are needed since the frost line extends to 4 feet below the surface in the winter. BNL and the local Suffolk County Fire Departments use National Standard Thread couplings.

BNL's Plant Engineering Division maintains the water supply system. BNL's Fire/Rescue Group conducts valve inspections on the distribution system to ensure reliability of firefighting water supplies.

5.1.2 Building Water Supply and Fire Department Connection

The RHIC is provided with a four-inch standpipe system with 1-1/2 inch hose outlets spaced every 100 feet around the perimeter.

5.1.3 Sprinkler Systems

There are no automatic sprinkler systems installed in the RHIC.

5.1.4 Fire Standpipe Systems

The RHIC is provided with a four-inch standpipe system with 1-1/2 inch hose outlets spaced every 100 feet around the perimeter. The class of the standpipe systems, as listed in the BCNYS, is “Class II” systems. The outlets are not provided with hose or nozzles, which is the acceptable practice.

5.1.5 Other Suppression Systems

There are no other fixed fire suppression systems in Building 1000.

5.2 Fire Alarm Systems

The facility is provided with a fire alarm system.

5.2.1 Building Fire Alarm System

The Building is provided with a fire alarm system consisting of smoke detectors spaced every 60 feet and manual fire alarm boxes located at the exit points and periodically around the enclosure.

5.2.2 Site Fire Alarm System

Brookhaven National Laboratory provides central fire alarm station coverage using a fault tolerant sever infrastructure based multiplexed Site Fire Alarm System. The system is an Andover Continuum; installed in 2005 (Andover is a part of Simplex Grinnell). The system complies with the requirements of NFPA 72 defined as a Style 6 Class "A" System.

Two mirrored servers are located in separate buildings. If the lead server fails the system automatically switches over to the working server. The Site Fire Alarm System operates on a fault tolerant high speed Ethernet infrastructure that utilizes network switches and fiber wiring between each of the major components.

The Site Fire Alarm System monitors fire alarm panels located throughout BNL by using the existing site telephone cable plant. RS232 signals are sent via full duplex line drivers. Each fire alarm panel has two channels connected to the Site Fire Alarm System. The panels are divided into 9 communication "loops." It is currently monitoring 9,700 points. Response time from alarm at the panel to alarm indication at the Central Station is less than 82 seconds, which is within the 90 seconds allowed by NFPA 72.

The main console is at the Firehouse, Bldg. 599. This station monitors all fire alarm signals, trouble and communication status alarms. A satellite station is provided at Safeguards and Security, Bldg. 50, and receives only the fire alarm signals. If the Firehouse does not acknowledge an alarm within 90 seconds, the satellite station at Bldg. 50 will receive an audible indication to handle the alarm. A second satellite station is provided at AGS Main Control Room, Bldg. 911, and receives only the fire alarm signals from the RHIC/AGS accelerator buildings. A team of Collider-Accelerator Control Room operators and Health Physics Support personnel respond during accelerator operating times.

5.3 Automatic Detection Systems

The building is provided with automatic detectors spaced approximately every 60 feet.

5.4 Fire Extinguishers

Fire extinguishers are provided in the building. The location and placement of portable fire extinguishers is in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*.

5.5 Smoke Exhaust System

A smoke removal system has been installed. The system provides ten air changes per hour with fresh air being supplied from the exit points (exit/equipment alcoves and stair entrances). Exhaust fans are located at mid points between exits.

6.0 FIRE HAZARDS

Fire hazard potentials are classified into four major categories; Special Occupancies, Unique Fire Hazards, Housekeeping in Vital Areas, Building Materials, Exterior Exposure Hazards, Natural Phenomenon Hazard Exposure, Toxic Fire Potential, Biological Fire Potential, and Radiation Fire Potential. The following is an evaluation of Building 1000 for each category.

6.1 Special Occupancies

Special occupancies include: instrumentation and data processing equipment, vital and important records, trailers, cooling towers, electrical substations, flammable liquid and gas storage, cables and raceways, . The special occupancies applicable to Building 1000 are expanded upon in Sections 6.1.1 thru 6.1.7, below.

6.1.1 Instrumentation and Data Processing Equipment

DOE/EP-0108 established levels of protection for Instrumentation and Data Processing equipment and the facility in which it is housed. The facility does not contain any significant instrumentation or data processing equipment and does not exceed any of the thresholds in DOE/EP-0108 for smoke detection, automatic sprinklers or fire barriers beyond the present level of protection.

6.1.2 Vital and Important Records Storage

Vital records are those records which are essential to the mission of an important program and which, if lost, could not be reproduced or obtained elsewhere. Important records are those records possessing a high value to the mission of an important program but which, if lost, could be reproduced or reconstructed with difficulty or significant extra expense.

Based on the above definitions, there are no vital records essential to the mission in this facility.

6.1.3 Trailers and Portable Structures

There are no trailers or portable structures associated with Building 1000.

6.1.4 Cooling Towers

There are no cooling towers associated with Building 1000.

6.1.5 Electrical Substations

Transformers do not present an exposure hazard to Building 1000.

6.1.6 Flammable Liquid & Gas Storage

The use of flammable liquids in the Building 1000 is minimal. The quantity of flammable gases and liquids in the facilities are less than the limits mandated by BCNYS Table 307.7(1) "*Maximum Allowable Quantity per Control Area of Hazardous Materials Posing a Physical Hazard*." Use of flammable liquids are in accordance with BNL ES&H Standards (found at https://sbms.bnl.gov/ld/ld08/ld08d481.pdf). The BNL Chemical Management System is designed to ensure that workers are informed about the chemical hazards in their workplace.

6.1.7 Cables and Raceways

Cable trays are easily accessible for manual fire fighting. Cable tray fires are not fast spreading. There is no early warning provided for the cable trays, thus the time to detection of a cable fire will be delayed, but manageable based on the automatic sprinklers in the building. This philosophy of easy access by manual fire fighting efforts and early warning detection (which is not present in this building) is described as acceptable in Factory Mutual Loss Prevention Data Sheet 5-31 "Cables and Buss Bars". Recovery time to repair damaged cables is expected to be less than 3 months, as the cable trays in Building 1000 are not excessive.

6.2 Unique Fire Hazards

The power supplies, RF amplifiers, magnet power supplies, and rectifiers/regulators for the DC power do not present any unique fire hazards. The power supplies are air, or water cooled.

6.3 Housekeeping in Vital Areas

Good housekeeping and control of combustibles was observed during this survey. The Collider-Accelerator department self-inspection program (Tier I) monitors routine experimental aspects. The BNL Plan Review Process screens conventional construction operations.

6.4 Building Materials

No significant amounts of exposed polystyrene insulation or other highly combustible building materials are used in the construction or operations at Building 1000. Therefore, no special fire protection precautions, beyond those that are generically described in this section, are required for this facility.

6.5 Exterior Exposure Hazards

Any exterior structure, area or piece of equipment that is subject to harmful effects from, or can cause harmful effects to this facility is defined as an exterior exposure. Exterior exposures can be categorized as: elements outside of the facility, and as components of the facility.

There are no exterior fire exposures to Building 1000, which is an underground tunnel.

6.6 Natural Phenomenon Hazard Exposure

Natural Hazards can be classified in five hazard categories: lightning, windstorm, wild fire, earthquake and flooding. The following is an evaluation for each category.

6.6.1 Lightning Potential

Based on NFPA standard 780 the lightning damage potential of the RHIC is minimal for this mostly below ground facility.

6.6.2 Windstorm Potential

The Long Island area basic wind speed (3-second gust) is 120 MPH based on Factory Mutual Data Sheet 1-28 and BCNYS figure 1609.4. The ground roughness exposure category for the area is 'Exposure B.' Based on the calculations this building should have roof assemblies classified as "Class 90" rated assemblies. This does not apply to this underground facility.

6.6.3 Brush Fire Potential

Based on the criteria presented for evaluating fire potentials from Wildland in the "*BNL Wildland Fire Interface Survey Report*," dated August 2002, there is no brush fire risk potential exposure to Building 1000.

Additionally, an analysis was completed consistent with the requirements and guidelines of NFPA 1144 *Protection of Life and Property from Wildfire* (2002) to determine the wildfire risk to Building 1000. The risk assessment was conducted in accordance with the Wildfire Hazard Severity Form checklist of NFPA 1144. The checklist is a summary of typical desirable characteristics found in various wildfire hazards analyses. Elements include emergency response ingress and egress, type of vegetation, topography, building construction and roofing materials, available fire protection, and utilities.

Based on the analysis, the hazard from wildfire to Building 1000 is "LOW" (score of 30, with 40 being the cut-off for low hazard). Specifics of the Wildfire Hazard Severity Analysis are shown in Appendix C of this report.

6.6.4 Earthquake Potential

The seismic damage potential for this facility is classified as low based on a Natural Hazards analysis produced for the BNL campus titled "*DOE Accelerator Order 5480.25 Implementation Plane for Brookhaven National Laboratory National Phenomena Hazards Evaluation*" dated April 1994. A low seismic classification means that the buildings and fire protection systems are not required to comply with seismic design standards.

6.6.5 Flooding Potential

Flood potential from bodies of water overflowing their normal levees is low for the BNL area. The flooding potential for this facility was classified as low in a Natural Hazards Analysis report produced for the BNL site, dated April 1994, titled "*DOE Accelerator Order 5480.25*

Implementation Plane for Brookhaven National Laboratory National Phenomena Hazards Evaluation."

Groundwater runoff from a severe rainstorm is not a concern for Building 1000 due to the surrounding terrain.

6.7 Toxic Fire Potential

Due to a system for diversion of radioactive liquid effluent to a hold-up pond, there are no environmental impacts due to release of contaminated water from the fire protection water system. Water sprayed on radioactive equipment may become slightly contaminated but would enter the sanitary system and be monitored before release. There are no significant amounts of combustible activated materials in the tunnels, rings, transport lines intersection regions or beam lines and no significant radioactive particles would be present in smoke. Therefore there is no significant environmental hazard from a fire at the C-AD facilities.

6.8 Biological Fire Potential

There are no known biological materials present in the building that present a release potential due to fire.

6.9 Radiation Fire Potential

The Collider-Accelerator Department accelerators are classified as low-hazard accelerator facilities, defined as those with the potential for no more than minor on-site and negligible off-site impacts to people and the environment. They are dependent upon external energy sources; that is, electrical power, that can be easily terminated. The primary hazard is prompt ionizing radiation that is limited to regions where the beam is maintained and is in existence only when a beam is present.

7.0 PRE-FIRE AND EMERGENCY PLANNING

The BNL Fire Department maintains an adequate pre-fire plan book for this facility **(**http://intranet.bnl.gov/emergencyservices/runcards/main_i.asp**).** The pre-plan was reviewed as part of this analysis.

7.1 Protection of Essential Safety Class Systems

There are no essential safety class systems associated with this non-nuclear facility.

7.2 Protection of Vital Programs

The operations associated with this facility are not considered to be a DOE vital program. Therefore, no special fire protection precautions, beyond those that are described in this report, are required for this facility.

7.3 Protection of High Value Property

High value equipment is generally regarded as any single item that is valued at $1 million or more, or where the loss of a single item could result in a loss of program continuity of greater than six months.

Based on this definition there is no high value equipment located within Building 1000. The power supplies, RF amplifiers, magnet power supplies have value and somewhat unique, but do not approach the definition of high value.

The highest value class of equipment appears to be the magnets which have an approximate value in the $100K range.

7.4 Critical Process Equipment

By DOE standards, critical process equipment is considered to be equipment which, if lost or damaged in a fire, could delay a significant component of a major program for a period in excess of 6 months.

There are a number of specialized magnets utilized in the RHIC, that if lost would impact experiments in the tunnel. It is not likely that a loss of any one of these devices would cause an outage to exceed 6-months.

7.5 Maximum Possible Fire Loss (MPFL) and Maximum Credible Fire Loss (MCFL)

The MPFL, as defined in DOE Order 420.1, is the value of property within a fire area, unless a fire hazard analysis demonstrates a lesser (or greater) loss potential, assuming the failure of both automatic fire suppression systems and manual fire fighting efforts. The fire loss estimate includes the replacement cost of equipment and property and any applicable decontamination and cleanup costs.

In accordance with the BNL Fire Safety Program, protection is required for facilities having an MPFL in excess of established thresholds as follows:

- When the MPFL exceeds $1 million an automatic sprinkler system designed in accordance with applicable NFPA standards is required;
- When the MPFL exceeds $25 million, a redundant fire protection system is required such that, despite the failure of the primary fire protection system, the loss will be limited to $25 million; and
- When the MPFL exceeds $50 million, a redundant fire protection system and a 3-hour fire resistance rated barrier are required to limit the MPFL to $50 million.

7.5.1 MPFL Scenario

The RHIC is considered one fire area and thus a single MPFL calculation is being performed.

Combustible loading throughout the building is relatively low and, with the exception of cables in cable trays there is a general lack of continuity of combustibles. Due to the overall volume of the facility, flashover is unlikely. Flashover indicates that the temperature inside an area would be sufficiently hot to cause multiple fuel package ignitions within the space and result in loss of all contents. Associated compartment temperatures at flashover are generally accepted to be between 500°C (900°F) to 600°C (1100°F). Flashover is generally defined as the transition from a growing fire to a fully developed fire. Fully developed fires impose extensive thermal and physical stresses on fire barriers, the failure of which could lead to fire spread throughout the area.

7.5.2 MPFL Calculation

The tunnel has a replacement value of approximately $40 million ($38,494,199). The building value was obtained from 2004 replacement costs. The average dollar density of the building is the replacement value divided by the floor area of the building $\$40,000,000/256,548ft^2 = \$156/ft^2$.

The content and equipment value is calculated based on the following assumptions:

- An average of $\$20/ft^2$ for content and equipment value within predominantly office areas, which does not apply to Building 1000.
- An average of $\$100/ft^2$ for content and equipment value within the industrial and experimental areas of the building.
- There were no available replacement costs provided for the equipment within Building 1000. For the purposes of this FHA the value is assumed to be approximately $40,000,000, based on the uniqueness of the various magnets and power supplies.

MPFL Summary

Attribute	Value
Building Value*	$40,000,000
Contents*	$40,000,000
MPFL Total (1% of total)	$800,000

*For this MPFL calculation, Building 1000 is considered a single fire area. Continuity of combustibles is not generally present throughout the building, therefore fire propagation and subsequent loss of contents and structure is unlikely. The RHIC is 12,578 LF with 2,578 LF of that taken up by the Experimental Halls. Thus 10,000 LF is represented by RHIC. It is assumed that a fire will damage equipment for a distance of 100 linear feet within the tunnel, or 1 percent The MPFL value is within the DOE limits.

7.5.3 MCFL Scenario

The MCFL, as defined in DOE Standard 1066-99 Fire Protection Criteria, is the value of property within a fire area, unless a fire hazard analysis demonstrates a lesser (or greater) loss potential. This assumes that all installed fire protection systems function as designed, and the effect of emergency response is omitted except for post-fire actions.

Without sprinkler protection the MCFL is the same as the postulated MPFL for that area.

MCFL Summary

Attribute	Value
Building Value*	$40,000,000
Contents*	$40,000,000
MPFL Total (1% of total)	$800,000

7.5.4 MPFL/MCFL Summary

Fire Area	MPFL	MCFL
Building 1000	$800,000	$800,000

7.6 Recovery Potential

Critical process parts have been identified by the Department. Critical process parts are those items essential to the operations and that require a long lead-time for replacement. It is unlikely that fire damage will result in a disruption of operations exceeding 6 months.

7.7 BNL Fire/Rescue Group

The BNL Fire/Rescue Group is a full time, paid department. Minimum staffing is five firefighters and one officer per shift. The firefighters are trained to meet Firefighter Level III by International Fire Service Training Association standard, National Fire Protection Association (NFPA) Fire Fighter Level II standard, and (NFPA) Hazardous Material Technician Level and they are Suffolk County Certified Confined Space Rescuers.

The BNL Fire/Rescue Group also provides emergency medical services to an on-site population of 3200 people. A minimum of two members per shift hold New York State “Emergency Medical Technician - D” certifications (“D” is for defibrillation). Normally all five firefighters have EMT status. The Group operates a New York State Certified Basic Life Support ambulance. Medivac services are available to BNL via the Suffolk County Police Department. Additionally the Fire/Rescue Group has two 1500 GPM "Class A" Pumpers, one Rescue Vehicle for initial hazardous material incident response and heavy rescue operation, and one Incident Command Vehicle.

The single Fire Station is located on the west side of the BNL Site. Response time to the most remote section of the BNL Site is less than eight minutes. Response time to Building 1000 is estimated at 5 minutes.

BNL participates in the Suffolk County Mutual Aid Agreement. This allows the resources from over 130 departments to assist BNL. BNL is also a member of the Town of Brookhaven Foam Bank. BNL has a mutual aid agreement for hazardous material incidents with the Town of Brookhaven and Stonybrook University.

7.8 Fire Apparatus Accessibility

Fire apparatus accessibility is adequate for the facility. Current parking lot configurations allow access by apparatus in the event of an emergency. Roadways are located on the north, east and south sides of the building.

7.9 Security Considerations Related to Fire Protection

The facility has limited security measures to restrict access (locked doors). Provisions have been made for Fire/Rescue access via provision of master key. The main entrances to the tunnel have a locked system that the FD can defeat for emergency access. There are door knobs/or break glass devices to permit egress in an emergency in the highly unlikely event someone is within the tunnel when it operates.

8.0 LIFE SAFETY CONSIDERATIONS

Life safety considerations for this facility include means of egress consisting of exit access, exits and exit discharge, exit signage, and emergency lighting. This building is required to comply with state building codes and NFPA 101®, the Life Safety Code (LSC). The requirements of both the 2002 edition of the Building Code of New York State (BCNYS) and the 2006 edition of the LSC have been applied to this analysis. It should be noted that the BCNYS is not intended to apply to existing structures. Appendix K of the BCNYS addresses alterations to existing structures. This building was likely constructed to comply with the latest version of the Life Safety Code NFPA 101 at the time of construction. DOE now requires all buildings to conform to local building codes and NFPA 101.

8.1 Occupancy Load Factor and Calculations

Occupancy load factor and calculations

The RHIC is only occupied for servicing the beamline equipment during outages. The maximum occupancy is dependent upon the type of service work being performed but is generally not expected to exceed 25 persons.

8.2 Means of Egress

The means of egress for the building meets the present code requirements for number and arrangement of exits, capacity of exits, travel distance, common path of travel, dead ends, and security considerations related to egress. The following subsections provide the egress detail for each of the elements.

8.2.1 Number and Arrangement of Exits

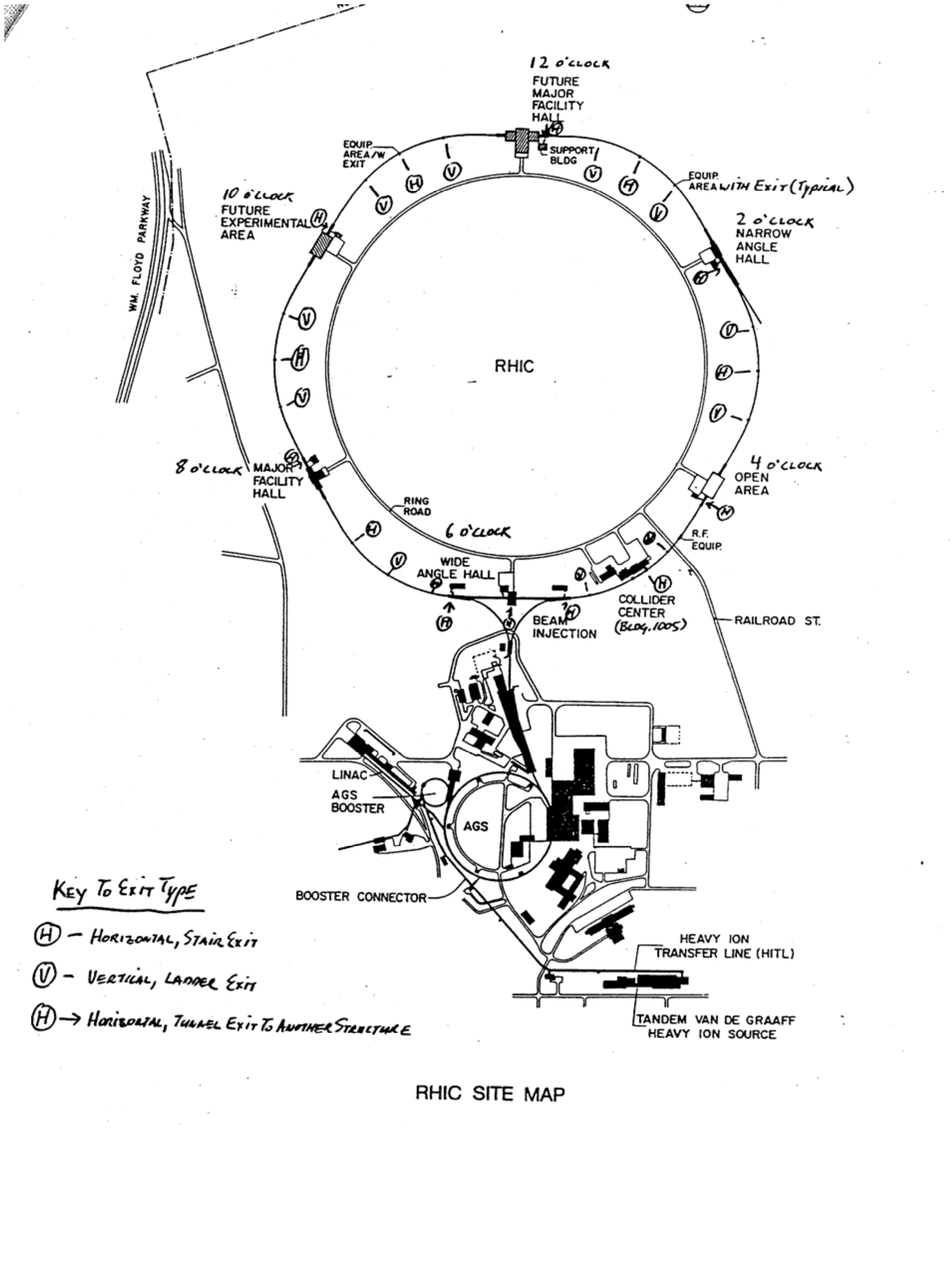
The LSC requires that a floor with an occupant load of 500 or fewer persons must have a minimum of two means of egress [§7.4.1.1]. Additional exits may be required for compliance with exit capacity or arrangement of exits criteria.

The RHIC has an adequate number of exits as shown in Figure 1. Sextant regions at the 1, 9 and 11 o'clock positions are equipped with five exits each. There are two types of exits; the first type is a standard exit, which has a set of stairs to the exterior; the second type is a ladder exit, in which the exit path leads through an exit/equipment enclosure alcove and then up a ladder to grade. The exits alternate between these two types, progressing around the Collider Ring. The experimental halls at the 2, 4, 6, and 8 o'clock positions provide one other exit at both ends of their structures. A utility tunnel connects the support buildings to the Collider Tunnel and provides an additional exit.

8.2.2 Capacity of Exits

The available exit capacity of Building 1000 exceeds the low occupant loading based on the BCNYS (Table 1003.2.3) and NFPA 101 (Table 7.3.3.1) for stairways and other egress components. Due to the low occupancy of the tunnel, the minimum 36 width is sufficient per Section §7.3.4.1.

Figure 1: RHIC Exit Locations



RHIC SITE MAP

8.2.3 Travel Distance

Building 1000 egress paths do not exceed the BCNYS and NFPA 101 travel distance limitations. BCNYS (Table 1004.2.4) limits egress travel distance to 300 feet in this type of unsprinklered F-2 occupancy. NFPA 101 (Table 40.2.6 and Section 40.2.6.3) limits egress travel distance to 300 feet in this type of unsprinklered Industrial Special Purpose occupancy.

Travel distance within the RHIC is approximately 220 feet, which complies with the maximum allowable of 300 feet for this facility.

8.2.4 Common Path of Travel

The building meets the common path of travel criteria found in Section 40.2.5.3 in the Life Safety Code.

8.2.5 Dead Ends

Per Section 40.2.5.2 of the Life Safety Code, and the Fire Code of New York State (FCNYS) (Table 1010.17.2) a dead end corridor cannot exceed 50 feet. The building is in compliance with this criterion.

8.2.6 Security Considerations Related to Fire Protection

The building does not have special access controls to restrict egress or fire rescue ingress.

8.2.7 Separation of Means of Egress

Where two exits or exit access doors are required, they must be located at a distance from one another not less than one-half the length of the maximum overall diagonal dimension of the building or area served [LSC §7.5.1.3.2; BCNYS §]. The building is provided with a two primary exits that are compliant, that meet this requirement.

8.3 Exit Signs and Emergency Lighting

Exit signage is required in accordance with Section 7.10 of the LSC. Exit signs should be placed in corridors and in rooms required to have at least two means of egress. Internally-illuminated exit signs and exit placards are provided in the building.

Emergency lighting for means of egress is required in accordance with Section 7.9 of the LSC. Emergency lighting is required in industrial occupancies [§40.2.9.1] except special-purpose industrial occupancies without routine human habitation. Emergency lighting is provided via an emergency generator.

8.4 Emergency Roof Exits

A means of escape is defined as a way out of a building or structure that does not conform to the strict definition of means of egress but does provide an alternate way out [LSC §3.3.152]. The building has no such arrangement.

8.5 Egress through Adjoining/Intervening Spaces

Exit access from rooms or spaces is permitted to be through adjoining or intervening rooms or areas, provided that such rooms or areas are accessory to the area served and the intervening rooms or areas are not spaces identified under Protection from Hazards (e.g., storage rooms) [LSC §7.5.1.6]. The building complies with this requirement.

8.6 Exit Discharge

Exits are required to terminate directly at a public way or at an exterior exit discharge. The LSC permits a maximum of 50 percent of the required number of exits to discharge inside the building provided the level of discharge is fully-sprinklered or the area of discharge is sprinklered and separated from the remainder of the building by fire barriers [§7.7.2.2; §7.7.2.4]. The criterion does not apply to Building 1000.

8.7 Horizontal Sliding Doors

There are no horizontal exit doors utilized in Building 1000.

8.8 Fire Escape Ladders

Fire escape ladders complying with 7.2.9 are permitted in industrial and business occupancies [§40.2.2.10; §39.2.2.10]. Fire escape ladders are permitted as means of egress only where one of the following conditions exists:

- Access to unoccupied roof spaces as permitted by 7.2.8.3.4.
- Secondary means of egress from boiler rooms or similar spaces subject to occupancy not to exceed three persons who are all capable of using the ladder.
- Means of egress from towers and elevated platforms around machinery or similar spaces subject to occupancy not to exceed three persons who are all capable of using the ladder.

Due to the unique nature of the facility, fire escape ladders are provided in the building as previously discussed.

8.9 Door Heights

Means of egress are required to provide a headroom clearance of not less than 6 ft 8 in. at doorways [LSC §7.1.5.1]. The existing doors meet this requirement.

8.10 Discharge to Roofs

Exits are permitted to discharge to roofs or other sections of the building where the following criteria are met and with approval by the authority having jurisdiction [LSC §7.7.6]:

- The roof/ceiling assembly construction has a fire-resistance rating not less than that required for the exit enclosure.
- A continuous and safe means of egress from the roof is available.

There are no exits that discharge to the roof of the building.

8.11 Barriers

8.11.1 Occupancy Separations

Occupancy separations are not required for Building 1000 since there is a single occupancy for the building.

8.11.2 Incidental Use Areas

Incidental use areas or hazardous areas are considered those spaces that pose a relatively higher hazard than the predominant occupancy of the area in which they are located. Such spaces are not necessarily classified as high-hazard (Group H) occupancies. Hazardous areas include general storage rooms, boiler or furnace rooms, and maintenance shops. The LSC requires hazardous areas to be separated from adjoining areas by a 1-hour fire resistance-rated barrier without windows or protected by automatic fire suppression systems [LSC §8.7.1.1]. Rooms with severe hazards such as maintenance shops with woodworking and painting are required to have both fire barrier enclosure and automatic fire suppression.

There are no such rooms associated with Building 1000.

8.11.3 Separation of Means of Egress

Not applicable to Building 1000.

8.11.4 Exit Access Corridors

There are no exit access corridors in Building 1000, thus this criterion does not apply.

8.11.5 Vertical Opening Barriers

Not applicable to Building 1000.

8.11.6 Egress Stairways

Egress stairways are provided around the Collider Ring. See Section 8.2.1.

8.12 Fire Protection Systems Required by Code

Automatic sprinkler protection is not required to address conditions found in the building.

8.13 Operational Requirements that are Required by Code

When performed, cutting and welding operations in the building are required to be conducted in accordance with NFPA 51B**,** *Standard for Fire Prevention during Welding, Cutting, and Other Hot Work*, 2003 Edition.

There are no other fire protection related operational requirements required by code.

9.0 REFERENCE DOCUMENTS

9.1 National Fire Protection Association

NFPA 10, *Standard for Portable Fire Extinguishers*, 2002 Edition

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2002 Edition

NFPA 30, *Flammable and Combustible Liquids Code*, 2003 Edition

NFPA 51B**,** *Standard for Fire Prevention during Welding, Cutting, and Other Hot Work*, 2003 Edition

NFPA 70, *National Electrical Code*®, 2005 Edition

NFPA 72®, *National Fire Alarm Code*®, 2002 Edition

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*, 2002 Edition

NFPA 101®, *Life Safety Code*®, 2006 Edition

NFPA 220, Standard on *Types of Building Construction*

NFPA 780, *Standard for the Installation of Lightning Protection Systems*, 2004 Edition

NFPA 1144, *Standard for Protection of Life and Property from Wildfire*, 2002 Edition

9.2 FM Global Loss Prevention Data Sheets

None.

APPENDIX A – FHA FIGURES

APPENDIX B –

LIGHTNING RISK CALCULATION

The expected lightning frequency (Nd) is **0.0** and the tolerable lightning frequency (Nc) is **0.0002**. Based on NFPA 780, If Nd > Nc, a lightning protection system should be installed.

Values of 0.00 were used for (A_e) because the tunnel is underground.

EXPECTED LIGHTNING STROKE FREQUENCY FROM NFPA 780 ANNEX L

$$N_d = (N_g)(A_e)(C_1)(10^{-6})$$

N_d = **0.0000** = yearly average flash density in the region where the structure is located

(N_g) = **2.0** = the yearly lightning strike frequency to the structure

(C_1) = **0.25** = the environmental coefficient

(A_e) = **0** = the equivalent collective area of the structure in square meters from calculation below

Length (L)	0	Feet
Width (W)	0	Feet
Height (H)	0	Feet
	0.25	

Figure H.4.2(a) Results 0 sq. meters

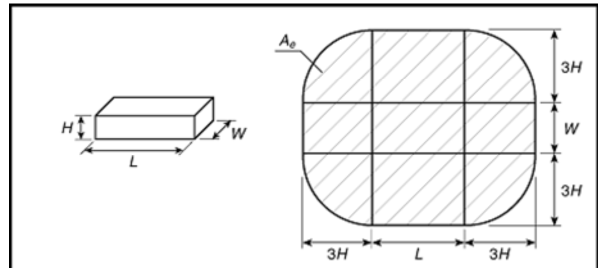
Figure H.4.2(b) Results 0 sq. meters

Table H.4.3 Determination of Environmental Coefficient C_1

Relative Structure Location	C_1
Structure located within a space containing structures or trees of the same height or taller within a distance of 3*H*	0.25
Structure surrounded by smaller structures within a distance of 3*H*	0.5
Isolated structure, no other structures located within a distance of 3*H*	1
Isolated structure on a hilltop	2

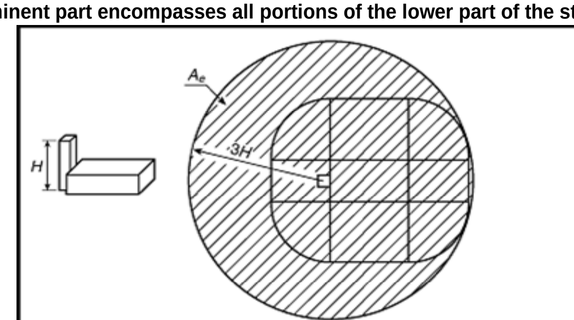
Assume
0.25

Figure H.4.2(a) Calculation of the equivalent collective area for a rectangular structure.



For a rectangular structure, $A_e = LW + 6H(L + W) + \pi 9H^2$.

Figure H.4.2(b) Calculation of the equivalent collective area for a structure where a prominent part encompasses all portions of the lower part of the structure.



Note: For a structure where a prominent part encompasses all portions of the lower part, $A_e = \pi 9H^2$

= input required

TOLERABLE LIGHTNING FREQUENCY FROM NFPA 780 APPENDIX L

$$N_c = \frac{1.5 \times 10^{-3}}{C}$$

where $C = (C_2)(C_3)(C_4)(C_5)$.

N_c = **0.0002**

Assume **1.0**

C_2 — Structural Coefficients			
	Roof		
Structure	**Metal**	**Nonmetallic**	**Flammable**
Metal	0.5	1.0	2.0
Nonmetallic	1.0	1.0	2.5
Flammable	2.0	2.5	3.0

Assume **2.0**

Structure Contents	C_3
Low value and nonflammable	0.5
Standard value and nonflammable	1.0
High value, moderate flammability	2.0
Exceptional value, flammable, computer or electronics	3.0
Exceptional value, irreplaceable cultural items	4.0

Assume **1.0**

Structure Occupancy	C_4
Unoccupied	0.5
Normally Occupied	1.0
Difficult to evacuate or risk of panic	3.0

Assume **5.0**

Lightning Consequence	C_5
Continuity of facility services not required, no environmental impact	1.0
Continuity of facility services required, no environmental impact	5.0
Consequences to the environment	10.0

= input required

APPENDIX C – Determination of Wildfire Hazard Severity

Using NFPA 1144

WILDLAND FIRE RISK AND HAZARD SEVERITY ASSESSMENT FORM
Appendix A, Figure A.4.2 from NFPA 1144

ELEMENT			POINTS
A.	**Means of Access**		
	1.	Ingress and egress	
		a. Two or more roads in/out	**0**√
		b. One road in/out	7
	2.	Road width	
		a. >= 24 ft	0
		b. >= 20 ft and < 24 ft	**2**√
		c. < 20 ft	4
	3.	All-season road condition	
		a. Surfaced road, grade <5%	**0**√
		b. Surfaced road, grade > 5%	2
		c. Non-surface road, grade < 5%	2
		d. Non-surface road, grade > 5%	5
		e. Other than all-season	7
	4.	Fire Service Access	
		a. <= 300 ft with turnaround	**0**√
		b. > 300 ft with turnaround	2
		c. < 300 ft with no turnaround	4
		d. >= 300 ft with no turnaround	5
	5.	Street Signs	
		a. Present	**0**√
		b. Not present	5
B.	**Vegetation (Fuel Models)**		
	1.	Characteristics of predominate vegetation within 300 ft.	
		a. Light (e.g., grasses, forbs, sawgrassess, and tundra) NFDRS Fuel Models A,C,L,N,S, and T	5
		b. Medium (e.g. light brush and small trees) NFDRS Fuel Models D,E,F,H,P,Q, and U	**10**√
		c. Heavy (e.g. dense brush, timber, and hardwoods) NFDRS Fuel Models B,G, and O	20
		d. Slash (e.g. timber harvesting residue) NFDRS Fuel Models J,K, and L	25
	2.	Defensible space	
		a. More than 100 ft of vegetation treatment from the structures	1
		b. 71 ft to 100 ft of vegetation treatment from the structures	3
		c. 30 ft to 70 ft of vegetation treatment from the structures	**10**√
		d. < 30 ft of vegetation treatment from the structures	25

C. Topography Within 300 of Structures

1.	Slope < 9%	**1**√
2.	Slope 10% to 20 %	4
3.	Slope 21% to 30%	7
4.	Slope 31% to 40%	8
5.	Slope > 41%	10

D. Additional Rating Factors

1.	Topographical features that adversely affect wildland fire behavior	0-5 [**0**√]
2.	Areas with a history of higher fire occurrence than surrounding areas due to special situations	0-5 [**0**√]
3.	Areas that are periodically exposed to unusually severe fire weather and strong dry winds.	0-5 [**0**√]
4.	Separation of adjacent structures that can contribute to fire spread	0-5 [**0**√]

E. Roofing Assembly

1.	Class A roof	0√ (underground structure)
2.	Class B roof	**3**
3.	Class C roof	15
4.	Nonrated	25

F. Building Construction

1.	Materials	
a.	Noncombustible/fire-resistive siding, eaves, and deck	**0**√
b.	Noncombustible/fire-resistive siding and combustible deck	5
c.	Combustible siding and deck	10
2.	Building setback relative to slopes of 30% or more	
a.	>= 30 ft to slope	1√
b.	< 30 ft to slope	5

G. Available Fire Protection

1.	Water source availability	
a.	Pressurized water source availability	
	500 gpm hydrants <= 1000ft apart	**0**√
	250 gpm hydrants <= 1000ft apart	1
b.	Nonpressurized water source availability	
	>= 250 gpm continuous for 2 hours	3
	< 250 gpm continuous for 2 hours	5
c.	Water unavailable	10
2.	Organized response resources	
a.	Station <= 5 miles from structure	**1**√

b.	Station > 5 miles from structure	3
3.	Fixed fire protection	
a.	NFPA 13	**0**
b.	None	5√
H.	**Placement of Gas and Electric Utilities**	
1.	Both underground	**0**√
2.	One underground, one aboveground	3
3.	Both aboveground	5
I.	**Total**	**30**

Hazard Assessment	Total Points
Low hazard	**< 40**
Moderate hazard	40-69
High hazard	70-112
Extreme hazard	> 112

A Wildfire Severity Level of 30 = A **LOW** Hazard